MEASURING UTILIZATION OF INDIVIDUAL
COMPONENTS OF CHANNELS

Technical Field

This invention relates, in general, to channel
5   subsystems and, in particular, to measuring utilization of
individual components of channels of a channel subsystem.

Background Art

Historically, the determination of channel utilization
has been important for capacity planning, problem analysis,
10   as well as for performance monitoring. Previously, the
utilization of a channel path has been measured by
accumulating the amount of time that a channel is busy
during predefined time intervals. These measurements
indicate how busy a channel was during each interval, and
15   based on the measurements, work management and planning
decisions were made.

With the advent of more complex channels (e.g., FICON
(Fibre Connections) channels offered by International
Business Machines Corporation), the previous techniques for
20   measuring channel utilization are inadequate. This is
because the new channels are considered a collection of
resources and an indication of the channel being busy does
not indicate in what capacity it is busy. Thus, a need
exists for an improved measurement of channel utilization.
25   In particular, a need exists for a capability that indicates
what portion of the channel is busy and the particular
utilization of that channel portion.

Summary of the Invention

The shortcomings of the prior art are overcome and additional advantages are provided through the provision of a method of determining utilization of channel components of a computing environment. The method includes, for instance, obtaining measurement data for a selected component of a channel, in which the channel includes a plurality of components; and using the measurement data to determine utilization of the selected component.

In one example, the method further includes obtaining one or more operational characteristics of the selected component, and in yet a further example, the one or more operational characteristics are used in determining the utilization of the selected component.

In a further aspect of the present invention, a method of obtaining information associated with channel components of a computing environment is provided. The method includes, for instance, selecting a channel within the computing environment to be monitored, the channel including a plurality of components; and obtaining data on one or more components of the plurality of components.

In one example, the obtaining data includes obtaining one or more operational characteristics of the one or more components. In a further example, the obtaining data includes obtaining measurement data usable in determining utilization of the one or more components.

In yet a further aspect of the present invention, a method of determining utilization of channels of a computing environment, in which the computing environment includes a plurality of logical partitions, is provided. The method

5   includes, for instance, obtaining measurement data for a channel, and using the measurement data to determine utilization of the channel. The measurement data is representative of use of the channel by the logical partition involved in determining the utilization and of use

10   by one or more other logical partitions of the plurality of logical partitions.

System and computer program products corresponding to the above-summarized methods are also described and claimed herein.

15   Additional features and advantages are realized through the techniques of the present invention. Other embodiments and aspects of the invention are described in detail herein and are considered a part of the claimed invention.

Brief Description of the Drawings

20   The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention are apparent from the following detailed

25   description taken in conjunction with the accompanying drawings in which:

FIG. 1 depicts one example of a computing environment incorporating and using the capabilities of the present invention;

FIG. 2a depicts one example of a channel utilization block used in accordance with an aspect of the present invention;

FIG. 2b depicts one example of a channel utilization entry of the channel utilization block of FIG. 2a, in accordance with an aspect of the present invention;

FIG. 3 depicts one example of a channel subsystem extended CPMF data area used in accordance with an aspect of the present invention;

FIG. 4 depicts one embodiment of various components of a channel of FIG. 1, in accordance with an aspect of the present invention;

FIG. 5 depicts one example of a channel processor universal CPMF data area used in accordance with an aspect of the present invention;

FIG. 6 depicts one embodiment of the logic used to set the appropriate mode for a channel processing measurement facility used in accordance with an aspect of the present invention;

FIG. 7 depicts one embodiment of the logic associated with an overview of how to determine

utilization of various components of a channel, in accordance with an aspect of the present invention;

FIG. 8 depicts one embodiment of the logic associated with an operating system determining the utilization of one or more channel components, in accordance with an aspect of the present invention;

FIG. 9a depicts one embodiment of a channel measurement characteristics block used in accordance with an aspect of the present invention;

FIG. 9b depicts one example of information included in the CMG-dependent channel measurement characteristics field of the block of FIG. 9a, in accordance with an aspect of the present invention;

FIG. 10 depicts one example of the command request block for a Set Extended Channel Measurements command used in accordance with an aspect of the present invention;

FIG. 11 depicts one embodiment of the logic associated with a channel processor collecting measurement data for one or more channel components, in accordance with an aspect of the present invention; and

FIG. 12 depicts one embodiment of the logic associated with an I/O processor storing measurement data for one or more channel components in channel utilization blocks, in accordance with an aspect of the present invention.

Best Mode for Carrying Out the Invention

     In accordance with an aspect of the present invention, channel utilization is measured. In particular, various individual components of a channel are monitored and
5   measured to determine the utilization of each particular component. Further, in accordance with another aspect of the present invention, when the system is in logical partition mode, the collected measurement data reflects the utilization of the channel (or channel component) by a
10   particular logical partition, as well as the utilization by other logical partitions in the system, which are coupled to the channel (or channel component).

     One embodiment of a computing environment incorporating and using the channel measurement capabilities of the
15   present invention is described with reference to FIG. 1. A computing environment 100 is based, for instance, on the Enterprise Systems Architecture (ESA)/390 offered by International Business Machines Corporation, Armonk, New York. ESA/390 is described in an IBM publication entitled
20   "Enterprise Systems Architecture/390 Principles of Operation," IBM Publication No. SA22-7201-06, July 1999, which is hereby incorporated herein by reference in its entirety. One example of a computing environment based on ESA/390 is the 9672 Parallel Enterprise Server offered by
25   International Business Machines Corporation.

     Computing environment 100 includes, for example, at least one central processing complex (CPC) 102 having one or more logical partitions (LPARs) 104, a hardware systems area (HSA) 106 and at least one channel subsystem 108.

The resources of the CPC are allocated to the logical
partitions. In particular, each logical partition 104 has
one or more logical processors (not separately shown for
clarity), each of which represents all or a share of a
5   physical processor allocated to the partition. The logical
processors of a particular partition may be either dedicated
to the partition (so that the underlying processor resource
is reserved for that partition) or shared with another
partition (so that the underlying processor resources are
10   potentially available to another partition).

In the particular example shown, each of logical
partitions 1-M functions as a separate system having a
resident operating system 109 (which may differ for each
logical partition). In one embodiment, the operating system
15   is the OS/390 or MVS/ESA operating system offered by
International Business Machines Corporation.

Further, each partition has a portion of the CPC's main
storage resources assigned to it and included within the
storage are channel utilization blocks 110. One example of
20   a channel utilization block 110 is described with reference
to FIGs. 2a-2b.

Referring to FIG. 2a, channel utilization block 110
includes one or more channel utilization entries 200, each
of which contains the utilization information for one
25   channel. In one example, channel utilization entry 200
includes the following fields:

        (A)   A channel-utilization-information validity
              (CUIV) map 202 that applies to the contents
              of the channel utilization entry. The bits

of the CUIV map indicate which words of the channel utilization entry contain valid channel utilization information;

(B)   A timestamp 204 that identifies when channel
5   utilization information was last stored in the channel utilization entry; and

(C)   CMG-dependent channel-utilization information
            206, the contents of which are dependent upon the channel measurement group (CMG) to which
10   the channel belongs. The program can determine the CMG for a channel by executing a Store Channel Measurement Characteristics command (described below) and examining the CMG field in the channel measurement
15   characteristics block (CMCB) (also described below) for the associated channel.

Various examples of values for CMG and the corresponding contents of fields of entry 200 include the following:

20   CMG=0: A value of 0 in the CMG field indicates that the channel-measurement group for the specified channel path identifier (CHPID) is unknown. The CUIV bits are zeros and the contents of the remainder of the channel-utilization entry have no meaning.

25   CMG=1: The CMG-dependent channel-utilization information for CMG=1 includes the following, in one example:

(A) Channel-Path-Busy Time (CPBT) (CPC): This field contains the accumulation of all measured channel-path-busy intervals for the associated channel path. The channel path is busy when it is actively communicating with an attached control unit or device.

When the CPC is operating in LPAR mode, the CPBT (CPC) value includes the channel-path-busy intervals associated with all of the logical partitions that have access to the associated channel path.

(B) Channel-Path-Busy Time: When the CPC is operating in LPAR mode, the channel path busy time contains the accumulation of measured channel-path-busy intervals for the associated channel path. The accumulation only includes intervals that are associated with the logical partition that has access to this channel utilization block. The channel path is busy when it is actively communicating with an attached control unit or device.

When the CPC is operating in basic mode (non-LPAR), the contents of this field have no meaning and the appropriate bit of the CUIV field is zero.

CMG-2: The CMG-dependent channel-utilization information for CMG=2 includes the following, in one example:

(A)   Count of Bus Cycles (CPC): This field
      contains an accumulated count of the internal
      bus cycles that have been used for I/O
      operations on the associated channel path.

5   When the CPC is operating in LPAR mode, the
      count includes the internal bus cycles that
      were used for I/O operations for all logical
      partitions that have access to the associated
      channel path.

10   (B)   Count of Channel Work Units (CPC): This field
      contains an accumulated count of the number
      of channel work units that have been
      performed by the associated channel path.

      When the CPC is operating in LPAR mode, the
15   count includes the channel work units that
      were performed for all logical partitions
      that have access to the associated channel
      path.

      (C)   Count of Channel Work Units: When the CPC is
20   operating in LPAR mode, this field contains
      an accumulated count of the number of channel
      work units that have been performed by the
      associated channel path.   The count includes
      only the channel work units that were
25   performed for the logical partition that has
      access to this channel utilization block.

      When the CPC is operating in basic mode, the
      contents of this field have no meaning and

the appropriate bit of the CUIV field is zero.

(D)   Count of Data Units Written (CPC): This field contains an accumulated count of the number of data units that have been written using the associated channel path.

The channel measurement characteristics block for the associated channel path specifies the number of bytes contained in a data unit.

When the CPC is operating in LPAR mode, the count includes the data units that were written for all logical partitions that have access to the associated channel path.

(E)   Count of Data Units Written: When the CPC is operating in LPAR mode, this field contains an accumulated count of the number of data units that have been written using the associated channel path. The count includes only the data units that were written for the logical partition that has access to this channel-utilization block.

When the CPC is operating in basic mode, the contents of this field have no meaning and the appropriate bit of the CUIV field is zero.

(F)   Count of Data Units Read (CPC): This field contains an accumulated count of the number

of data units that have been read using the
associated channel path. The channel
measurement characteristics block for the
associated channel path specifies the number
5   of bytes contained in a data unit.

When the CPC is operating in LPAR mode, the
count includes the data units that were read
for all logical partitions that have access
to the associated channel path.

10   (G)   Count of Data Units Read: When the CPC is
operating in LPAR mode, this field contains
an accumulated count of the number of data
units that have been read using the
associated channel path. The count includes
15   only the data units that were read for the
logical partition that has access to this
channel-utilization block.

When the CPC is operating in basic mode, the
contents of this field have no meaning and
20   the appropriate bit of the CUIV field is
zero.

Returning to FIG. 1, coupled to the logical partitions
is a hardware systems area (HSA) 106 which, in this
embodiment, includes a channel subsystem extended CPMF data
25   area 112. The channel subsystem extended CPMF data area
includes measurement information for individual channels, as
described with reference to FIG. 3. In particular, for each
channel, the data area includes, for instance, channel
measurement characteristics 300, total measurement data 302,

and measurement data 304 for each particular operating system associated with the specified channel. Further details regarding these fields are provided below.

Channel measurement characteristics 300 of a channel
5   include, for example, maximum bus cycles specifying the maximum internal bus cycles per second, available for I/O operations on the specified channel path; maximum channel work units specifying the maximum number of channel work units that can be performed per second by the specified
10   channel paths; maximum write data units specifying the maximum number of data units that can be written per second using the specified channel path; maximum read data units specifying the maximum number of data units that can be read per second using the specified channel path; and data unit
15   size specifying the number of bytes of data that are contained in the data unit for the specified channel path.

Total measurement data 302 includes the total measurements for specified characteristics of a channel. In one example, the total measurement data includes the total
20   bus cycles, the total work units, the total written data units and the total read data units, as explained further below.

Additionally, the channel measurement data per operating system includes the measurements of the specified
25   characteristics on a per operating system basis.

Referring again to FIG. 1, also coupled to the HSA is channel subsystem 108, which is used in communicating with input/output (I/O) devices. Channel subsystem 108 directs the flow of information between the input/output devices and

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main storage.   It relieves the central processing units of the task of communicating directly with the input/output devices and permits data processing to proceed concurrently with input/output processing.

5   In one embodiment, channel subsystem 108 includes one or more I/O processors 114 coupled to one or more channels 116.   Further, coupled to each channel is a physical channel link 118 that is used to communicate with the I/O devices. In particular, in one example, the link couples the channel

10   to a control unit, which is further coupled to one or more I/O devices.

Further details regarding a channel are described with reference to FIG. 4.   In one embodiment, each channel 116 includes, for instance, a channel processor storage 400

15   coupled to a host-bus bridge and DMA controller 402 for providing access, via a system bus 404, to the operating system and other components of the CPC.   Additionally, coupled to the host-bus bridge and DMA controller is an internal bus 406, which is coupled to a channel processor

20   408 and an adapter card 410.   The adapter card provides access to the I/O devices via an external link 412.

One example of a channel is a FICON channel offered by International Business Machines Corporation.   One example of a FICON channel is described in "IBM S/390 FICON

25   Implementation Guide", IBM Publication No. SG24-5169-00 (Nov. 1999), which is hereby incorporated herein by reference in its entirety.

In one embodiment, channel processor storage 400 includes a channel processor universal CPMF data area 414

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used in storing various measurement information for the channel. As shown in FIG. 5, channel processor universal CPMF data area 412 includes, for instance, channel measurement characteristics 500, total channel measurement

5   data 502, and measurement data 504 for each operating system coupled to the channel.

Channel measurement characteristics data 500 includes, for instance, maximum units 506 for a channel component. For example, maximum units 506 includes the maximum bus

10   cycles (e.g., for Component 1 -- the internal bus) of the channel, the maximum channel work units (e.g., for Component 2 -- the channel processor), the maximum write data units (e.g., for Component 3 -- the external link), and the maximum read data units (e.g., for Component 4 -- the

15   external link) for the channel.

Total channel measurement data 502 includes the total measurements for the components (e.g., the total bus cycles, total work units, total written data units and the total read data units).

20   Similarly, the operating system measurement data includes an operating system timestamp 514, as well as accumulated units 516 for each operating system of a component. Again, this is the accumulated information for each component.

25   Described in detail above is one example of a computing environment incorporating and using aspects of the present invention. The above-described environment is only one example, however. Other computing environments can be used without departing from the spirit of the invention.

Further, for one or more aspects of the present invention, the computing environment need not be in logical partitioning (LPAR) mode. Basic mode (non-LPAR) can also benefit from aspects of the present invention.

~~Channel subsystems are further described in Casper et al., U.S. Patent No. 5,526,484, entitled "Method and System for Pipelining the Processing of Channel Command Words," issued on June 11, 1996, as well as in Galbraith et al., U.S. Patent No. 5,265,250, entitled "Channel Measurement~~

10   ~~Method and Means," issued on November 23, 1993, each of which is hereby~~ incorporated herein by reference in its ~~entirety.~~

        In accordance with an aspect of the present invention, various components of the channel are individually

15   measurable. These components include, for instance, internal bus 406, channel processor 408, and external link 412. By measuring these components individually, specific information about the individual components, as well as about the channel as a whole, can be gathered and employed

20   in work management decisions, billing situations, system performance, as well as other areas.

        Each of the various components is measured using a channel path measurement facility (CPMF). The channel path measurement facility may be initiated under various

25   conditions, as described with reference to FIG. 6. As one example, the operating system may run the channel path measurement facility when an initial program load (IPL) is performed, STEP 600. As a further example, the operating system runs the channel path measurement facility when an

30   operator selects an SRM parmlib member using an OS/390 Set

command, STEP 602. As a further example, the operating
system may run the channel path measurement facility when an
operator configures a channel path (CHPID) online, STEP 604.

5   Regardless of the triggering event for initiating the
channel path measurement facility, a determination is made
as to whether the parmlib specifies a channel path
measurement facility (CPMF) keyword, INQUIRY 606. In
particular, a decision is made as to whether the systems
programmer chose to run with a parmlib member that
10   specifically indicated the desired CPMF mode (e.g.,
compatibility mode, CPMF=COMPAT, in which the individual
components are not measured; or extended mode,
CPMF=EXTENDED, in which the individual components are
measured in accordance with aspects of the present
15   invention).

         If the CPMF keyword was specified, then the system
operates in the mode selected, STEP 608. However, if the
systems programmer did not specifically set the CPMF
parameter, then the operating system chooses the CPMF mode
20   based on the set of channel path ids found in the machine.
In particular, a determination is made as to whether an
extended measurement mode CHPID is found, INQUIRY 610. If
any of the online CHPIDs desire extended mode for gathering
the performance data, then CPFM is initialized in extended
25   mode, STEP 612. Otherwise, if no CHPIDs desiring extended
mode are found, the system runs in the old compatibility
mode, STEP 614. This completes initialization of the
channel path measurement facility in the desired mode, STEP
616.

In one embodiment, both the compatibility mode and the extended mode can be active at the same time. That is, one facility can be activated in one mode, and another facility can be activated in another mode. This is true for both the

5   same logical partition and across multiple logical partitions.

Assuming that the channel path measurement facility is set to extended mode, the channel path measurement facility collects data on the various components of the channel, in

10   accordance with an aspect of the present invention. An overview of one embodiment of the logic employed to collect the various data is described with reference to FIG. 7.

Initially, a Store Channel Measurement Characteristics CHSC command is used by the operating systems to learn about

15   the measurement characteristics (or attributes) of each channel that is to be measured, STEP 700. That is, the operating systems learn about the characteristics of the various components of the channel to be measured. In one example, the measurement characteristics include the maximum

20   bus cycles, which is an attribute of internal bus 406 (FIG. 4); maximum channel work units, which are attributes of channel processor 408; and maximum written/read data units, which are attributes associated with external link 412. Further, the characteristics include the data unit size.

25   In addition to using the Store Channel Measurement Characteristics CHSC command to learn about the measurement attributes, a Set Extended Channel Measurements CHSC command (described below) is used by the operating system to start the channel path measurement facility and to provide to the

I/O processor a program data area for the channel
utilization blocks, STEP 702.

Thereafter, each channel processor collects measurement
data, via, for instance, the channel path measurement
5   facility, for the various channel components contained in
that channel and places the data in channel processor
universal CPMF data area 414 (FIG. 4) contained in channel
processor storage 400. Then, at each proper interval, the
data is copied from data area 414 to channel subsystem
10   extended CPMF data area 112 (FIG. 1) for that channel, STEP
704.

Additionally, the I/O processor collects from each of
the channel subsystem extended CPMF data areas the data for
all of the channels, reformats it and stores it in the
15   channel utilization blocks in the previously provided
program data area, STEP 706. The operating system then
observes the information that has been placed in the channel
utilization blocks and is able to interpret the information
using the measurement characteristics that apply to each
20   channel that were previously gathered (in STEP 700), STEP
708. This interpreted information provides the utilization
of the measured channel components.

Further details regarding the processing performed by
the various units of the central processing complex to
25   measure the utilization of the individual components of a
channel are described with reference to FIGs. 8-12. In
particular, FIG. 8 describes one embodiment of the
processing performed by one or more of the operating
systems; FIG. 11 depicts one embodiment of the logic
30   performed by one or more of the channel processors; and FIG.

12 depicts one embodiment of the logic performed by one or more of the I/O processors.

Referring to FIG. 8, initially, the operating system collects the channel measurement characteristics data for
5   each channel associated with that operating system, using the Store Channel Measurement Characteristics CHSC command, STEP 800. As one example, the command request block for the store command includes an op code specifying the Store Channel Measurement Characteristics command, as well as an
10 identifier for each channel path (CHPID) for which information is requested.

In response to this request, a command response block for the Store Channel Measurement Characteristics command is provided. This response block includes, for instance, one
15 or more channel measurement characteristics blocks. In particular, a channel measurement characteristics block may be stored for one or more of the specified CHPIDs, beginning with the CHPID specified by the first CHPID field. One example of a channel measurement characteristics block is
20 described with reference to FIG. 9a.

In one example, a channel measurement characteristics block 900 includes, for instance, one or more flags 902, a channel path identifier (CHPID) 904, a channel measurement characteristics validity (CMCV) indicator 906, a channel
25 measurement group (CMG) 908 and a channel measurement group-dependent measurement characteristics field 910, each of which is described below.

Flags 902 provide indicators that enable the proper interpretation of the information in the channel measurement

characteristics block. As one example, flags 902 include a non-valid (N) indicator which, when zero, indicates that information is provided in the channel measurement characteristics block for the associated channel path. The

5   CMG and CMCV fields indicate which information is provided. When one, the non-valid bit indicates that information is not provided for the associated channel path and the CMCV field is all zeros.

Flags 902 also include a shared channel path (S)
10   indicator, which is meaningful when the N bit is zero and the CPC is operating in LPAR mode. When zero, the S bit indicates that the associated channel path is not shared between the logical partition executing the Store Channel Measurement Characteristics command and other logical
15   partitions. When one, the S bit indicates that the associated channel path may be shared between the logical partition executing the Store Channel Measurement Characteristics command and one or more of the logical partitions.

20   CHPID 904 contains the channel path id of the channel path with which this channel measurement characteristics block is associated.

Channel measurement characteristics validity (CMCV) indicator, when one, indicates that the channel path
25   measurement facility stores channel measurement characteristics information in the corresponding word of the channel measurement characteristics block. When zero, a CMCV bit indicates that the contents of the corresponding word of the channel measurement characteristics block have
30   no meaning.

Channel measurement group (CMG) 908 specifies the measurement group to which the specified CHPID belongs. This value determines the contents and format of the CMG-dependent channel measurement characteristics area, and the

5   format and contents of the channel utilization entry for the associated channel path, in the channel utilization block, described above.

CMG-dependent channel measurement characteristics 910 includes information which is dependent upon the value

10   specified in the channel measurement group field. For instance, a value of zero in the CMG field indicates that the channel measurement group for the specified CHPID is unknown. Thus, the CMCV bits are zeros and the contents of block 910 have no meaning. Further, when CMG=1, the CMCV

15   bits are zeros, and again, the contents of block 910 have no meaning.

However, when the CMG field contains a value of 2, the CMG-dependent channel measurement characteristics include, for instance, the following: maximum bus cycles 912 (FIG.

20   9b); maximum channel work units 914; maximum write data units 916; maximum read data units 918; and a data unit size 920, each of which is described above.

Returning to FIG. 8, in addition to collecting the channel measurement characteristics data for each channel,

25   the operating system starts the channel path measurement facility using a Set Extended Channel Measurement CHSC command, STEP 802. The Set Extended Channel Measurement command starts or stops the channel facility based on the operation requested in the request block of the command. If

30   the channel path measurement facility is to be started, one

facility is provided, when the CPC is operating in basic
mode. However, when the CPC is operating in LPAR mode, one
channel path measurement facility is provided for each
logical partition. The phrase "the channel path measurement

5   facility" used herein implies the CPC channel path
measurement facility, when the CPC is operating in basic
mode, or the channel path measurement facility associated
with the logical partition executing the command, when the
CPC is operating in LPAR mode. One example of the request

10   block used for the Set Extended Channel Measurement command
is described with reference to FIG. 10.

In one example, a command request block 1000 for the
Set Extended Channel Measurement command includes an
operation code 1002 specifying the operation to be

15   performed. In one example, this code may indicate a start
of the channel path measurement facility for the Set
Extended Channel Measurements command; a stop of the channel
path measurement facility for the Set Extended Channel
Measurements command; or a test of the status of the channel

20   path measurement facility for the Set Extended Channel
Measurements command.

Additionally, the command request block includes a key
1004 used by the channel path measurement facility to access
the channel utilization block. Further, it includes

25   utilization block addresses 1006. When the operation code
specifies a start operation, the channel utilization block
addresses contain the absolute addresses of, for instance,
two 4k-byte areas in main storage which collectively make up
the channel utilization block. Each part (i.e., 4k area) of

30   the channel utilization block contains utilization
information for a unique set of a predefined number (e.g.,

128) of channel paths. When the operation code specifies a stop or a test operation, the contents of the channel utilization block address is ignored.

In response to executing the Set Extended Channel
5   Measurement command, a response block is provided. This response block, indicates, for instance, the results of executing the Set Extended Channel Measurement command.

The channel path measurement facility provides the program (e.g., operating system) with the ability to
10   accumulate channel path utilization information, and to accumulate the portion of shared channel path utilization attributable to a logical partition, when the CPC is operating in LPAR mode.

Returning to FIG. 8, subsequent to starting the channel
15   path measurement facility, the channel subsystem begins to accumulate channel measurement data into the associated channel utilization block at predefined intervals (e.g., at least once every four seconds), STEP 804. One example of how this is performed is described below with reference to
20   FIGs. 11 and 12.

Thereafter, the operating system determines the utilization of a particular channel component (such as, for instance, the channel processor, the internal bus or the external link), which is referred to herein as Component X,
25   STEP 806.

One embodiment of how the operating system performs this determination is described with reference to STEP 808. For example, a copy of the channel utilization block, called

Sample # 1, is saved. Then, after a predefined delay (e.g., 15 seconds), another copy of the channel utilization block, called Sample # 2, is also saved. Subsequently, the "change in channel Component X units" between the sample periods is

5   calculated by subtracting the count of channel Component X units from Sample # 1 from the count of channel Component X units from Sample # 2. (For example, the count of bus cycles for the internal bus of Sample # 1 is subtracted from the count of bus cycles for the internal bus of Sample # 2.

10   Similar computations are made for the various characteristics of the other components.)

Additionally, the "change in channel time" between the sample periods is calculated by subtracting the channel timestamp for Sample # 1 from the channel timestamp for

15   Sample # 2. Thereafter, the "average change in channel Component X units per second" during this sample period is calculated by dividing the change in channel Component X units by the change in channel time. The utilization of channel Component X, during the sample period, is then

20   calculated by dividing the "average change in channel Component X units per second" by the maximum channel component units per second from the channel measurement characteristics.

Subsequent to determining the utilization of a channel

25   Component X, processing proceeds to STEP 804 in order to continue to collect and analyze data for another of the various channel components.

As mentioned above, in addition to the operating system performing tasks relevant to determining the utilization of

channel components, the channel processor also performs various tasks needed to collect measurement data relating to a measurable channel component. One embodiment of the logic associated with collecting this data is described with

5   reference to FIG. 11.

Initially, the channel processor is reset and initialized, STEP 1100. Thereafter, the channel processor stores its channel measurement characteristics (CMC) into the channel subsystem extended CPMF data area in the HSA,

10   STEP 1102. Subsequently, a determination is made as to whether channel work is pending, INQUIRY 1104. In one example, this determination is made by checking an internal status indicator. If no work is pending, then no data need be collected, thus processing continues with INQUIRY 1106.

15   At INQUIRY 1106, a determination is made as to whether a predefined time period (e.g., at least two seconds) has passed since the HSA channel measurement data has been updated. If the predefined amount of time has not elapsed, then processing continues with INQUIRY 1104. However, if

20   the predefined time interval has passed, then the channel's copy of the measurement data is stored into the HSA, STEP 1108. In particular, the data stored in the channel processor universal CPMF data area is copied to the channel subsystem extended CPMF data area. Thereafter, processing

25   continues with INQUIRY 1104.

At INQUIRY 1104, if channel work is pending, then the requested I/O operation is performed for the specified operating system, STEP 1110. Additionally, measurement data related to the current I/O operation is collected for each

30   measurable channel component, STEP 1112. The new measurement

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data is then added to the accumulated measurement data for the particular operating system and to the accumulated total channel measurement data in the channel processor universal CPMF data, STEP 1114. Additionally, the measurement data

5 timestamp is updated. Thereafter, processing continues with INQUIRY 1106.

Processing related to the I/O processor's collection of data is described with reference to FIG. 12. Initially, a set loop count is set equal to a variable M, where M is

10 equal to the number of operating systems, STEP 1200. Thereafter, a determination is made as to whether the extended channel path monitoring facility is active for this operating system, INQUIRY 1202.

If the facility is not active for this operating

15 system, then the loop count is decremented by a predefined amount (e.g., by one), and a determination is made as to whether the last operating system has been processed, INQUIRY 1204. If the last operating system has been processed, then the logic polls for other IOP work to

20 perform, STEP 1206. Otherwise, processing continues with INQUIRY 1202 for the next operating system.

At INQUIRY 1202, if the extended monitoring facility is active for this operating system, then a channel count is set equal to a variable, N, which reflects the number of

25 channels, STEP 1208. Thereafter, the total measurements data and the operating system measurement data for the channels in which the operating system has access are fetched from the channel subsystem extended CPMF data area of the HSA and stored into the operating system's channel

30 utilization blocks, STEP 1210. Subsequently, the variable,

channel count, is decremented by a predefined amount (e.g., one), and a determination is made as to whether the last channel has been processed, INQUIRY 1212. If the last channel has been processed, then processing continues with

5   INQUIRY 1204. Otherwise, processing continues with STEP 1210.

Described in detail above is a measurement facility that measures utilization of individual channel components. This advantageously provides utilization information in

10   enough detail (e.g., work units, data units written, data units read and bus cycles used) to effectively assess the workload of a channel. Advantageously, measurements are provided that are tailored to the type of channel path, and which are meaningful in determining how, and to what degree,

15   the channel is being utilized. The utilization measurements of the present invention include information concerning both the CPC level and the single logical partition level. In addition, in one aspect of the present invention, an operating system that is executing in a logical partition

20   under LPAR is able to observe channel path utilization for all logical partitions, as well as for its own logical partition.

Although various components are described herein, this invention is not limited to those components. Aspects of

25   this invention are universal and can be used with a wide range of components. Further, the characteristics described herein are only examples. Other characteristics can be used without departing from the spirit of the present invention.

The present invention can be included in an article of

30   manufacture (e.g., one or more computer program products)

having, for instance, computer usable media. The media has embodied therein, for instance, computer readable program code means for providing and facilitating the capabilities of the present invention. The article of manufacture can be included as a part of a computer system or sold separately.

Additionally, at least one program storage device readable by a machine, tangibly embodying at least one program of instructions executable by the machine to perform the capabilities of the present invention can be provided.

The flow diagrams depicted herein are just examples. There may be many variations to these diagrams or the steps (or operations) described therein without departing from the spirit of the invention. For instance, the steps may be performed in a differing order, or steps may be added, deleted or modified. All of these variations are considered a part of the claimed invention.

Although preferred embodiments have been depicted and described in detail herein, it will be apparent to those skilled in the relevant art that various modifications, additions, substitutions and the like can be made without departing from the spirit of the invention and these are therefore considered to be within the scope of the invention as defined in the following claims.